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ABSTRACT

This paper reports on a computer simulation of cloze retrieval tasks. It first outlines the ideas that were assembled and translated into the model used to compose the simulation and describes the method used in developing the simulation. It then reports on a comparison of the time required by a computer and by human subjects in responding to cloze items of one, two, and three semantic constraints. Results indicated that the computer responses showed a similar relation between time and constraint to that noted in human responses. The paper includes an illustration of the theoretical model of the cloze procedure and graphs of computer and human response time for cloze retrieval tasks. (GW)

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COMPUTER SIMULATION OF CLOZE PERFORMANCE

Michael C. McKenna

The purpose of this study was to simulate the retrieval aspect of the cloze process and to use the simulation in various comparisons with human performance. Traditionally, the rationale of simulation attempts has been that if a computer program can succeed in duplicating a cognitive task, then the logical principles underlying such a program "could in fact be the same as those describing the design and functioning of the living organism" (Hilgard & Bower, 1975, p. 429). This study goes somewhat beyond the fact of duplication and compares resultant machine behavior with that of actual cloze subjects.

Writing of the simulation was guided principally by the results of several studies. Weaver (1965) was one of the first to describe cloze as having a memory-search component, and Treisman (1965) provided evidence that a list-search hypothesis was more likely than alternative

CS 003 936

retrieval systems. In particular, her results suggest that sequential rather than parallel processing is the more probable. And in fact, most assumptions of human cognition have had a sequential bias (Dutton & Briggs, 1971) so that most computer simulations of memory, the present one included, have been sequential (Winograd, 1976).

Tuinman (1972) speculated on the probable aspects of cloze retrieval from the results of Kaplan, Carvellas, and Metlay (1971), who had found that the average time required by subjects to respond to a given cloze item increases with the amount of context. Tuinman inferred that the additional time could be explained only by assuming that the set of memory elements searched contains unacceptable (nontarget) words.

McKenna (1977) attempted to confirm and expand this finding by providing subjects with items which varied not in the number of words but in the number of countable semantic constraints on the deleted word. It was found that average response time increased with the number of constraints although the increase was only marginally significant between items of 2 and 3 constraints. While this finding was generally consonant with that of Kaplan et al., the nonlinear relationship between time and constraint was not easily explained and in fact led to the present study.

McKenna also found that erroneous responses tended to meet some portion of the constraints present. This result, with the preceding one, was interpreted to mean that the set of elements searched during retrieval is comprised of words associated with one constraint and that the process is largely one of checking such words for the satisfaction of additional constraints.

The order in which the words are checked appears to be that of the associative strength between each word and the characteristic used for retrieval. For example, an item calling for a kind of fruit would more likely be answered with apple than with pomegranate since the former is associated much more strongly with the concept of fruit. A test of this principle was incorporated into the McKenna study. Each of the items used was based on one of the 56 familiar categories (e.g., fruit) normed by Battig and Montague (1969). High correlations were observed between the frequencies of cloze responses and the corresponding Battig-Montague frequencies. Moreover, these correlations were unaffected by the presence of additional constraints so that the order of search would appear to be relatively rigid, a result obtained in a related earlier study (Weaver, Kingston, & Dinnan, 1971).

These ideas were assembled and translated into the model (Figure 1) used to compose the simulation.

Insert Figure 1 about here

Method

Had the object been to simulate the entire cloze process, an extremely sophisticated language-understanding program would have been necessary, encompassing the key areas of syntax, semantics, inference, and generation (Jackson, 1974). But because only the retrieval (generation) phase was of interest here, the simulation program was confined to the last third of the model--the operations occurring after the lo-

cation of the examination subset. These steps were translated into PL/I, a language chosen both for its universality and for its verbal capacity. The resulting program was straightforward:

```
CLØZ: PRØCEDURE ØPTIØNS (MAIN);
DECLARE (WØRD(100,2),ITEM) CHARACTER (20) VARYING,
   (C,I,J,K,N) BINARY FIXED (12);
ØN ENDFILE (SYSIN) GØ TØ D2;
N = 0;
GET EDIT(ITEM,C)(A(20),F(2,0));
D1: DØ I = 1 TØ 100;
 GET SKIP EDIT(WØRD(I,1),WØRD(I,2))(A(20),A(5));
 N = N + 1;
END D1;
D2: DØ J = 1 TØ N;
 D3: DØ K = 1 TØ C:
  IF SUBSTR(WØRD(J,2),K,1) ¬= SUBSTR(ITEM,K,1) THEN GØ TØ S1;
  IF K = C THEN GØ TØ S2;
 END D3;
S1: END D2;
S2: PUT EDIT(WØRD(J,1))(A(20));
END CLØZ;
```

Reconstructing an examination subset for each item was somewhat speculative. It was understood that the resultant machine memory was to represent that of the "typical" cloze subject, so that the most frequent human responses were the ones invariably generated by the computer. For items of only one semantic constraint, the examination subset consisted of only one word--the response given most frequently by the human population. According to the model, the single constraint (e.g., fruit) activates a "file" of words associated with it, and these words are considered in the order of associative strength. Since all of the words meet the constraint, the first word considered proves to be an acceptable response and is generated. This word (e.g., apple)

is of course the one most strongly associated with the category name. For practical purposes, it was unnecessary to construct an examination subset larger than one word since the search concluded with the first word considered.

But for items of more than a single constraint, the situation was more complex. First, according to the model, one of the constraints is used to locate the examination subset. By definition, all of these words meet that constraint, but not all of them meet the remaining constraints. Then, again according to the model, the words are considered individually in an effort to find one which does meet all of the constraints. As before, the order of search is the order of associative strength between each word and the constraint used for defining the examination subset. Thus, for each item the computer's examination subset was taken to be the list of words produced by the Battig-Montague population in response to the same constraint. This list was scanned until a word satisfying the additional constraint(s) was found. For example, if the first constraint were "fruit" and the second "yellow," the computer would begin with the most strongly associated fruit (apple) and proceed until a yellow fruit were encountered. In cases where the first Battig-Montague word meeting all of the constraints was not the same as the most frequent response given by subjects in the McKenna study, the former was excluded from the list in an effort to make the computer memory as representative as possible of the human population with which it would be compared.

Results and Discussion

Of principal interest was the time required by a computer which had been equipped with the memory of a "typical" cloze subject to respond to items of 1, 2, and 3 semantic constraints. A graphic representation both of computer and human response latencies under these conditions appears in Figure 2.

Insert Figure 2 about here

While visual comparisons can be misleading when the vertical axes differ, it is nonetheless clear that the simulation varies from linearity in the same way that the human population varied--a greater increase in time occurring between 1 and 2 constraints than between 2 and 3.

This result strongly tends to confirm the model of cloze retrieval (Figure 1) on the basis of which the simulation was written. Moreover, in exhibiting a similar relationship between time and constraint, the computer has made it possible to suggest that the departure from linearity was due to the specific items used, the particular categories chosen from Battig and Montague. That is, had different categories been chosen, with different patterns of memory storage, then a different relationship would have been exhibited. It is unlikely, however, that any alteration of the categories used would eliminate the monotonic increase of response time with the number of constraints.

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Figure 1. A theoretical model of the cloze procedure*

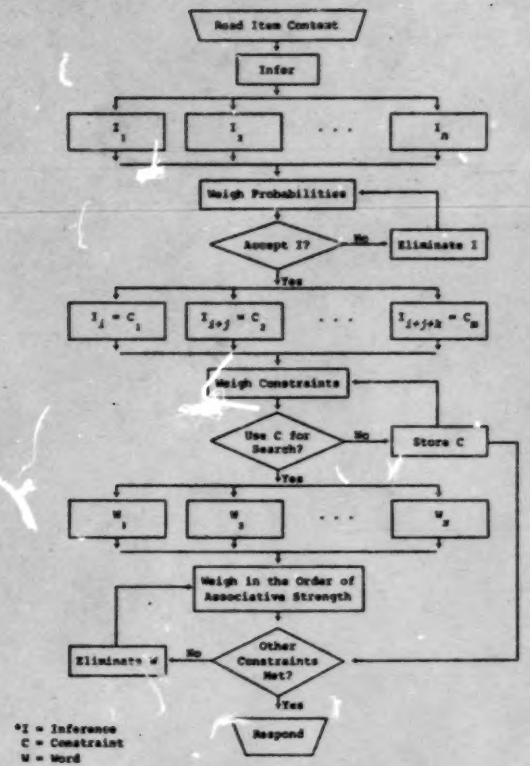

Figure 2. Response time of computer (above) and human subjects (below) as a function of the number of semantic constraints